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**PASSENGER AIRBAG AND METHOD****Cross Reference To Related Applications**

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This application claims priority to and the benefit of U. S. Provisional Patent Application Serial Number 60/216,213, filed July 6, 2000, and hereby incorporated by reference.

**Field of the Invention**

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The present invention relates to a passenger airbag or airbag cushion which simultaneously exhibits a very low amount of fabric utilized to produce the target airbag cushion in correlation to an overall high amount of available inflation airspace within the cushion itself. These two correlative elements are combined in what is defined as an effective fabric usage index (being the quotient of the amount of fabric utilized in the construction of the airbag cushion and the available inflation airspace volume) and a fabric weight index (being the quotient of the total weight of fabric utilized in the construction of the airbag cushion and the available inflation airspace volume). A cushion exhibiting low seam usage, fabric weight factor, and fabric usage factor and also comprising an integrated looped pocket for the disposition of an inflator can is also provided as well as an overall vehicle restraint system including the inventive airbag cushion.

**Background of the Invention**

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All U.S. patents cited herein are hereby fully incorporated by reference. Inflatable protective cushions used in passenger vehicles are a component of relatively complex passive restraint systems. The main elements of these systems are: an impact

5 sensing system, an ignition system, a propellant material, an attachment device, a system enclosure, and an inflatable protective cushion. Upon sensing an impact, the propellant is ignited causing an explosive release of gases filling the cushion to a deployed state which can absorb the impact of the forward movement of a body and dissipate its energy by means of rapid venting of the gas. The entire sequence of events occurs within about 100  
10 milliseconds. In the undeployed state, the cushion is stored in or near the steering column, the dashboard, in a door, or in the back of a front seat placing the cushion in close proximity to the person or object it is to protect.

Inflatable cushion systems commonly referred to as air bag systems have been used  
15 in the past to protect both the operator of the vehicle and passengers. Systems for the protection of the vehicle operator have typically been mounted in the steering column of the vehicle and have utilized cushion constructions directly deployable towards the driver. These driver-side cushions are typically of a relatively simple configuration in that they function over a fairly small well-defined area between the driver and the steering column.  
20 One such configuration is disclosed in U.S. Patent 5,533,755 to Nelsen et al., issued July 9, 1996, the teachings of which are incorporated herein by reference.

Inflatable cushions for use in the protection of passengers against frontal or side impacts must generally have a more complex configuration since the position of a vehicle  
25 passenger may not be well defined and greater distance may exist between the passenger and the surface of the vehicle against which that passenger might be thrown in the event of a collision. Prior cushions for use in such environments are disclosed in U.S. Patent 5,520,416 to Bishop, issued May 28, 1996; U. S. Patent 5,454,594 to Krickl issued October

5 3, 1995; U.S. Patent 5,423,273 to Hawthorn et al. issued June 13, 1995; U.S. Patent  
5,316,337 to Yamaji et al. issued May 31, 1994; U.S. Patent 5,310,216 to Wehner et al.  
issued May 10, 1994; U.S. Patent 5,090,729 to Watanabe issued February 25, 1992; U.S.  
Patent 5,087,071 to Wallner et al. issued Feb. 11, 1992; U.S. Patent 4,944,529 to Backhaus  
issued July 31, 1990; and U.S. Patent 3,792,873 to Buchner et al. issued February 19, 1974,  
10 all of which are incorporated herein by reference.

The majority of commercially used restraint cushions are formed of woven fabric  
materials utilizing multifilament synthetic yarns of materials such as polyester, nylon 6 or  
nylon 6,6 polymers. Representative fabrics for such use are disclosed in U.S. Patent  
15 4,921,735 to Bloch issued May 1, 1990; U.S. Patent 5,093,163 to Krummheuer et al. issued  
March 3, 1992; U.S. Patent 5,110,666 to Menzel et al. issued May 5, 1992; U.S. Patent  
5,236,775 to Swoboda et al. August 17, 1993; U.S. Patent 5,277,230 to Sollars, Jr. issued  
January 11, 1994; U.S. Patent 5,356,680 to Krummheuer et al. October 18, 1994; U.S.  
Patent 5,477,890 to Krummheuer et al. issued December 26, 1995; U.S. Patent 5,508,073  
20 to Krummheuer et al., issued April 16, 1996; U.S. Patent 5,503,197 to Bower et al. issued  
April 2, 1996 and U.S. Patent 5,704,402 to Bowen et al. issued January 6, 1998, all of which  
are incorporated herein by reference.

As will be appreciated, the permeability of the cushion structure is an  
25 important factor in determining the rate of inflation and subsequent rapid deflation following  
the impact event. In order to control the overall permeability of the cushion, it may be  
desirable to use differing materials in different regions of the cushion. Thus, the use of  
several fabric panels in construction of the cushion may prove to be a useful design feature.

5 The use of multiple fabric panels in the cushion structure also permits the development of relatively complex three dimensional geometries which may be of benefit in the formation of cushions for passenger side applications wherein a full bodied cushion is desired. While the use of multiple fabric panels provides several advantages in terms of permeability manipulation and geometric design, the use of multiple fabric panels for use in passenger  
10 side restraint cushions has historically required the assembly of panels having multiple different geometries involving multiple curved seams.

As will be appreciated, an important consideration in cutting panel structures from a base material is the ability to maximize the number of panels which can be cut from a fixed  
15 area through close-packed nesting of the panels. It has been found that minimizing the number of different geometries making up panels in the cushion and using geometries with substantially straight line perimeter configurations generally permits an enhanced number of panels to be cut from the base material. The use of panels having generally straight line profiles has the added benefit of permitting the panels to be attached to one another using  
20 substantially straight seams or to be substantially formed during the weaving process using a jacquard or dobby loom. Such a straight seam configuration provides a more cost-effective method of producing such airbags. The term "seam" denotes any manner or method of connecting separate fabric panels or separate portions of a single fabric panel. Thus, sewing (with thread, for example), welding (with ultrasonic stitching, for example), or weaving  
25 panels or portions together (with a jacquard or dobby loom, for example), and the like, may be employed for this purpose.

However, even with the utilization of substantially straight seams to produce airbags

5 cushions, a problem still resides in the need for labor-intensive cutting and sewing operations for large-scale manufacture. Furthermore, since the costs of producing airbag fabrics are relatively high and there is a general need to reduce such costs, there is a consequent need to more efficiently make use of the fabric by lowering the amount which needs to be cut (cutting operations also translate into higher labor costs), reducing the  
10 amount of fabric used in order to provide substantially lower packing volumes (in order to reduce the size of the airbag modules in cars since available space on dashboards, doors, and the like, are at a premium within automobiles), and reducing the shipping weight of such products (which translates into lower shipping costs), as well as other highly desired reasons.

However, it has been problematic to reduce such utilized fabric amounts in the past without  
15 consequently also reducing the available inflation airspace volume within the cushion product. There is a need then to reduce the amount of time to produce airbag cushions while simultaneously providing the lowest amount of fabric and simultaneously allow for a sufficient volume of air (gas) to inflate the target airbag cushion during an inflation event (herein described as "available inflation airspace"). Such a desired method and product has  
20 not been available, particularly for passenger-side airbags which, as noted previously require greater amount of fabric for larger volumes of air (gas) to provide the greatest amount of protection area to a passenger. With greater amounts of fabric needed, generally this has translated into the need for longer seams to connect and attach fabric panels, which in turn translates into greater amounts of time needed for sewing, and the like, operations.

25 Furthermore, there is a need for simultaneously reducing the required amount of utilized fabric while providing sufficient volumes of available inflation airspace within the target airbag cushion. Also, a need exists to produce high available inflation airspace volume airbag cushions with a minimal requirement in fabric utilization, fabric weight and/or seam

5 usage to manufacture the overall cushion product.

### Summary of the Invention

In view of the foregoing, it is a general object of the present invention to provide a  
10 cost-effective, easy to manufacture airbag cushion for utilization within a vehicle restraint  
system. The term "vehicle restraint system" is intended to mean both inflatable occupant  
restraining cushion and the mechanical and chemical components (such as the inflation  
means, ignition means, propellant, and the like). It is a more particular object of the present  
invention to provide a vehicle restraint system wherein the target airbag cushion preferably  
15 comprises very low amounts or weights of fabric and/or comprises all substantially straight  
seams to attach its plurality fabric components together (although as noted above, other  
configured seams may also be used as long the overall required effective seam usage factor  
is met). A further object of this invention is to provide an easy-to-assemble airbag cushion  
which is minimally labor-intensive to manufacture, requires much lower fabric costs due to  
20 a substantial reduction in the overall requirement of utilized fabric amounts, and which also  
comprises an integrated looped pocket for the disposition of an inflator can within the airbag  
cushion. It is still a further object of this invention to provide a vehicle restraint system  
comprising an airbag cushion which provides the maximum amount of available inflation  
airspace volume simultaneously with the lowest length of seam (or seams) and/or lowest  
25 weight or amount of utilized fabric necessary to manufacture the cushion. Another object  
of the invention is to provide a method of making a low cost airbag cushion (due to low  
levels of labor required to sew the component parts together and reduced amount of fabric  
to manufacture and cut) of simple and structurally efficient design. It is still another object

5 of the present invention to provide a passenger side top mount airbag cushion or passenger airbag formed by precutting a slit in the fabric in the main panel (near the bottom portion or the side portion of the bag) so that when a seam is sewn to connect or close the slit, the fabric gathers around the seam to create an off set in the mount.

10 To achieve these and other objects and in accordance with the purpose of the invention, as embodied and broadly described herein, the present invention provides an airbag cushion having at least one fabric component, wherein said airbag cushion possesses an effective fabric usage factor of less than about 0.0330, more preferably less than about 0.020 and a fabric weight factor of less than about 8.0, more preferably less than about 3.0.

15 The effective fabric usage factor is derived from an effective fabric usage index which concerns (and is defined as) the quotient of the total amount of fabric utilized to manufacture the airbag cushion (measured in square meters) over the total volume of available inflation airspace within the airbag cushion (measured in liters). In order to exhibit a sufficiently low effective fabric usage factor, the amount of fabric must be very low with a correspondingly

20 high available inflation airspace volume. The fabric weight index is defined as the quotient of the total weight of fabric utilized in the construction of the airbag cushion and the available inflation airspace volume. Of course, this airspace volume will be the same for each factor since the measurements of the factors (seam usage, fabric usage and fabric weight) are made for the same bag. Such an airbag cushion may comprise at least two

25 separate fabric panels or a single panel with portions which require connection (preferably through the utilization of at least one substantially straight seam). The inventive bag is able to provide high available inflation airspace volumes due to the particular configurations of the used fabric panels or portions. The configurations permit more efficient utilization of

5 fabric webs by cutting panels from the webs and producing less waste of unused fabric. The preferred embodiment is discussed in greater detail below.

The effective fabric usage factor (as defined within the correlating seam usage index formula, above) for the inventive airbag cushion then is preferably less than about 0.0330, more preferably less than 0.030, still more preferably less than 0.028, even more preferably less than 0.026, yet more preferably lower than 0.023, and most preferably lower than 0.020. Thus, the volume of available inflation airspace within the airbag cushion should be as great as possible with the amount of fabric utilized reduced to its absolute minimum while still providing sufficient protection to a passenger in an automobile during a collision event.

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The effective fabric weight factor (as defined within the correlating seam usage index formula, above) for the inventive airbag cushion then is preferably equal to or less than about 8.0, more preferably less than 7.0, still more preferably less than 6.0, even more preferably less than 5.0, yet more preferably lower than 4.0, and most preferably lower than 3.0. Thus, the volume of available inflation airspace within the airbag cushion should be as great as possible with the weight of fabric utilized reduced to its absolute minimum while still providing sufficient protection to a passenger in an automobile during a collision event.

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25 A driver-side airbag will generally comprise a low amount of utilized fabric but also does not provide a correlative high volume of available airspace; and the prior art passenger-side airbags require large amount of fabric. Although the available inflation airspace volume in such passenger-side airbags is rather large, the total amount of utilized fabric is too large

5 to meet the aforementioned preferred effective fabric usage or weight factors within that index. The inventive cushion therefore is relatively easy to manufacture, requires very low sewing, or similar type, attachment operations of its fabric panel components, requires very low amounts or weight of fabric, but is also configured to provide an optimum large amount of available inflation airspace for maximum protection to a passenger during a collision  
10 event.

The present invention also provides in at least one embodiment an airbag cushion possessing the required effective fabric usage factor which also comprises a looped pocket for introduction of the inflator can of an inflator assembly. The most preferred embodiment  
15 includes two mirror-image body panel sections adapted to be joined by two substantially straight seams along corresponding lateral boundary edges. Any boundary segments of the body panels which are not joined to one another are joined around the perimeter of a, preferably, rectilinear panel by a series of short, substantially straight seams. Such a configuration thereby forms a looped pocket in the airbag as well as an overall inflatable  
20 cushion structure. The airbag itself need not be created from two mirror-image body panel sections as any configuration of fabric panels will function properly in this invention as long as a three-dimensional inflatable cushion is formed during an inflation event and a looped pocket is created in the airbag in which the at least the inflator can of an inflator assembly is disposed.

25 Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice for the invention. It is to be understood that both the foregoing general

- 5 description and the following detailed description of preferred embodiments are exemplary and explanatory only, and are not to be viewed as in any way restricting the scope of the invention as set forth in the claims.

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### Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several potentially preferred embodiments of the invention and together with the description serve to explain the principles of the invention wherein:

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**FIG. 1** is an aerial view of a portion of a fabric web with lines indicating the specific preferred locations for cutting to form two sets of fabric panels to manufacture two separate inventive cushions, each for the inclusion within a vehicle restraint system configured within a module which is stored substantially vertically.

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**FIG. 2** is an aerial view of a preferred cut fabric panel with second and third smaller preferred cut panels connected thereto.

**FIG. 3** is an aerial view of the connected preferred cut fabric panels showing the first folding step in producing the mouth portion of the target cushion.

**FIG. 4** is an aerial view of the connected preferred cut fabric panels showing the second folding step in producing the mouth portion of the target cushion.

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**FIG. 5** is an aerial view of the connected preferred cut fabric panels showing the third folding step in producing the mouth portion of the target cushion as well as the entire connected fabric panel composite folded over and connected to itself.

**FIG. 6** is an aerial view of the preferred cut fabric front panel of the target cushion.

5           **FIG. 7** is a front view of the unfinished target cushion showing the preferred front panel and the substantially straight seams connecting the front panel to the remaining preferred cut fabric panels.

**FIG. 8** is a side view of the finished, unfolded, and non-inflated, target cushion.

**FIG. 9** is a cut-away side view of a vehicle for transporting an occupant illustrating  
10 the deployment of an inflatable restraint cushion within a vehicle restraint system according to the present invention.

**FIG. 10** is an aerial view of a portion of a fabric web with lines indicating the specific preferred locations for cutting to form two sets of fabric panels to manufacture two separate inventive cushions, each for the inclusion within a vehicle restraint system  
15 configured within a module which is stored substantially horizontally.

**FIG. 11** is an aerial view of a preferred cut fabric panel with second and third smaller preferred cut panels connected thereto.

**FIG. 12** is an aerial view of the connected preferred cut fabric panels showing the first folding step in producing the mouth portion of the target cushion.

20           **FIG. 13** is an aerial view of the connected preferred cut fabric panels showing the second folding step in producing the mouth portion of the target cushion.

**FIG. 14** is an aerial view of the connected preferred cut fabric panels showing the third folding step in producing the mouth portion of the target cushion as well as the entire connected fabric panel composite folded over and connected to itself.

25           **FIG. 15** is an aerial view of the preferred cut fabric front panel of the target cushion.

**FIG. 16** is a front view of the finished target cushion showing the preferred front panel and the substantially straight seams connecting the front panel to the remaining preferred cut fabric panels.

5           **FIG. 17** is a side view of the finished, unfolded, and non-inflated, target cushion.

**FIG. 18** is a cut away side view of a vehicle for transporting an occupant illustrating the deployment of an inflatable restraint cushion within a vehicle restraint system according to the present invention.

**FIG. 19** is an aerial view of a portion of a fabric web with lines indicating the  
10 specific preferred locations for cutting to form two sets of fabric panels to manufacture two separate inventive cushions, each which provide means for an integrated mouth to form a pocket for the disposition of an inflation can therein.

**FIG. 20** is an aerial view of a preferred cut fabric panel with second and third smaller preferred cut panels connected thereto.

15           **FIG. 21** is an aerial view of the connected preferred cut fabric panels showing the entire connected fabric panel composite folded over and connected to itself.

**FIG. 22** is an aerial view of the preferred cut fabric front panel of the target cushion.

**FIG. 23** is a front view of the finished target cushion showing the preferred front panel and the substantially straight seams connecting the front panel to the remaining  
20 preferred cut fabric panels.

**FIG. 24** is a top view of the finished, unfolded, and non-inflated, target cushion.

**FIG. 25** is a side view of the finished, unfolded and non-inflated, target cushion including the integrated mouth structure for the disposition of an inflation can therein.

**FIG. 26** is a cut-away view of a vehicle for transporting an occupant illustrating the  
25 deployment of an inflatable restraint cushion within a vehicle restraint system according to the present invention.

**FIG. 27** is an aerial view of a portion of a fabric web with lines indicating the specific locations for cutting to form six separate passenger airbag cushions.

5           **FIG. 28** is an aerial view of a portion of a fabric web with lines indicating the specific preferred locations for cutting to form two sets of fabric panels to manufacture two separate inventive top mount airbag cushions, each for the inclusion within a vehicle restraint system configured within a module.

**FIG. 29** is a schematic side view of an inflated front mount airbag.

10          **FIG. 30** is a schematic side view illustration of an inflated top mount airbag.

### Description of the Preferred Embodiments

15          Reference will now be made in detail to potentially preferred embodiments of the invention, examples of which have been illustrated in the accompanying drawings. The groupings of **FIGS. 1-9, 10-18, and 19-26** each represent different embodiments. It is to be understood that it is in no way intended to limit the invention to such illustrated and described embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the true spirit and scope of the invention as defined by the appended claims and equivalents thereto.

20                 Turning now to the drawings, wherein like elements are denoted by like reference numerals throughout the various views, in **FIG. 1** there is shown fabric web 10, wherein eight fabric panels to be cut 12,14,16,18,20,22,24, and 26 have been outlined. Also, specific fabric pieces to be removed and slits 28,30,32 within the two largest fabric panels 12,14 are outlined as well. The fabric web 10 in this specific example comprised nylon 6,6, 630 denier yarns, woven on a jacquard loom into a fabric 10 comprising 41 picks by 41 ends per

5 inch.

In **FIG. 2**, two smaller preferred fabric panels 16,18 have been connected to one preferred large fabric panel 12 by substantially straight seams 34,36,38,40. The composite fabric structure now has two small fabric portions 39,41 uncovered by the two smaller fabric panels 16,18. The free space 30 remains and an imaginary straight line 42 denotes the future fold line within the fabric composite of the fabric panels 12,16,18.

In **FIG. 3**, plastic rods at the mouth or tie-rods 31,44 have been placed over the small fabric portions 39, 41 parallel to the seams 38,40, and the fabric portions 39,41 have been folded back in a manner to form a right angle at the point of contact between the two portions 39,41.

In **FIG. 4**, the small fabric portions 39,41 have been folded over once again and seams 35, 37 have been produced to connect the fabric portions 39,41 to themselves and to the smaller fabric panels 16,18. The folded over fabric portions 39,41 provide reinforcements in order to withstand inflation pressures at the mouth opening of the cushion.

In **FIG. 5**, the fabric panel 12 has been folded over imaginary line 42 (in half) leaving one smaller fabric panel 16 in view (the other is not illustrated as it is now located on the bottom portion of fabric panel 12 directly beneath smaller fabric panel 18). A seam 46 connects fabric panel 12 to itself and also connects the smaller fabric panels 16, 18 both to the larger panel 12 and to themselves. Upon unfolding of the connected composite, the non-connected ends of the panel 12 will form the same shape as the front panel 24 of **FIG. 6**. **FIG. 7** then shows the seam 48 needed to sew the non-connected ends of the larger panel 12 (of **FIG. 5**), and **FIG. 8** provides a side view of the finished cushion 50 after all the

connections through seams 34, 35, 46 have been made.

**FIG. 9** shows a fully deployed inflatable restraint cushion 50 in opposing relation to an occupant 52 located on the front seat 54 of a vehicle 56 such as an automobile, airplane, and the like. As shown, the cushion 50 may be outwardly deployed from the dash panel 57 through an inflation means 58 from a position directly opposite the occupant 52.

It is to be understood, however, that the cushion 50 may likewise be deployed from any other desired location in the vehicle including the steering wheel (not illustrated), the vehicle side panels (not illustrated), the floor (not illustrated), or the backrest of the front seat 54 for disposition in opposing relation to a rear passenger (not illustrated).

In **FIG. 10** there is shown a fabric web 110, wherein eight fabric panels to be cut 112, 114, 116, 118, 120, 122, 124, and 126 have been outlined. Also, specific slits 128, 129, 130, 132 within the two largest fabric panels 112, 114 are outlined as well. The fabric web 110 in this specific example comprised nylon 6, 6, 630 denier yarns, woven on a jacquard loom into a fabric 110 comprising 41 picks by 41 ends per inch.

In **FIG. 11**, two smaller preferred fabric panels 116, 118 have been connected to one preferred large fabric panel 112 by substantially straight seams 144, 146, 148. The composite fabric structure now has two small fabric portions 131, 150, 152 uncovered by the two smaller fabric panels 116, 118, which is noticeably off-center in order to ultimately allow for the bag to be deployed at an angle from a horizontally disposed dashboard (not illustrated).

In **FIG. 12**, tie-rods 153, 155 have been placed over the small fabric portions 150, 152 which have been folded back over the tie-rods 153, 155 as shown, folded again, as in **FIG. 13**, and connected to themselves by seams 152, 156. The folded over fabric portions 150, 152 provide reinforcement in order to withstand inflation pressures at the mouth

5 opening of the cushion.

In **FIG. 14**, the fabric panel 112 has been folded over imaginary line 142 leaving one smaller fabric panel 116 in view (the other is not illustrated as it is now located on the bottom portion of fabric panel 112 directly beneath smaller fabric panel 118). A seam 158 connects fabric panel **112** to itself and also connects the smaller fabric panels 116, 118 both  
10 to the larger panel 112 and to themselves. Upon unfolding the connected composite, the non-connected ends of the panel 112 will form the same shape as the front panel 124 of **FIG. 15**. **FIG. 16** then shows the seam 159 needed to sew the non-connected ends of the large panel 12 (of **FIG. 14**), and **FIG. 17** provides a side view of the finished cushion 160.

**FIG. 18** shows a fully deployed inflatable restraint cushion 160 in opposing relation  
15 to an occupant 162 located in the front seat 164 of a vehicle 166 such as an automobile, airplane, and the like. As shown, the cushion 160 may be outwardly deployed from the dash panel 167 through an inflation means 168 from a position directly opposed the occupant 162. It is to be understood, however, that the cushion 160 may likewise be deployed from any other desired location in the vehicle 166 including the steering wheel (not illustrated), the  
20 vehicle side panels (not illustrated), the floor (not illustrated), or the backrest of the front seat 164 for disposition in opposing relation to a rear passenger (not illustrated).

In **FIG. 19** there is shown a fabric web 210, wherein eight fabric panels to be cut 212, 214, 216, 218, 220, 222, 224, and 226 have been outlined. Also, specific fabric pieces to be removed and slits 228, 230, 232 within the two largest fabric panels 212, 214 are  
25 outlined as well. The fabric web 210 in this specific example comprised nylon 6, 6, 630 denier yarns, woven on a jacquard loom into a fabric 210 comprising 41 picks by 41 ends per inch.

In **FIG. 20**, two smaller preferred fabric panels 216, 218 have been connected to one

5 preferred large fabric panel 212 by substantially straight seams 234, 236, 238, 240. An imaginary straight line 242 denotes the future fold line within the fabric composite of the fabric panels 212, 216, 218.

In **FIG. 21**, the fabric panel 212 has been folded over imaginary line 242 (in half) leaving one smaller fabric panel 216 in view (the other is not illustrated as it is now located  
10 on the bottom portion of fabric panel 212 directly beneath smaller fabric panel 218). A seam 244 connects fabric panel 212 to itself and also connects the smaller fabric panels 216, 218 both to the larger panel 212 and to themselves. Upon folding the connected composite, the non-connected ends of the panel 212 will form the same shape as the front panel 224 of **FIG. 22**. **FIG. 23** then shows the seam 252 needed to sew the non-connected ends of the larger  
15 panel 212 (of **FIG. 21**), and **FIG. 24** provides a top view of a finished cushion 260 and **FIG. 25** provides a side view of the finished cushion 260 after all the connections through seams 234, 244, 248 have been made.

**FIG. 26** shows a fully deployed inflatable restraint cushion 260 in opposing relation to an occupant 262 located on the front seat 264 of a vehicle 266 such as an automobile,  
20 airplane, and the like. As shown, the cushion 260 may be outwardly deployed from the dash panel 267 through an inflation means 268 from a position directly opposite the occupant 262. It is to be understood, however, that the cushion 260 may likewise be deployed from any other desired location in the vehicle 266 including the steering wheel (not illustrated), the vehicle side panels (not illustrated), the floor (not illustrated), or the backrest of the front  
25 seat 264 for disposition in opposing relation to a rear passenger (not illustrated).

These specific configurations and shapes provide the lowest overall fabric usage as compared to the available inflation airspace volume. Specific measurements for each

5 inventive cushion manufactured in this configuration (but with different amounts of fabric utilized) are further described in Tables 3 and 4, below.

Each of these panels may be formed from a number of materials including by way of example only and not limitation woven fabrics, knitted fabrics, non-woven fabrics, films  
10 and combinations thereof. Woven fabrics may be preferred with woven fabrics formed of tightly woven construction such as plain or panama weave constructions being particularly preferred. Such woven fabrics may be formed from yarns of polyester, polyamides such as nylon 6 and nylon-6,6 or other suitable material as may be known to those in the skill in the art. Multifilament yarns having a relatively low denier per filament rating of not greater than  
15 about 1-4 denier per filament may be desirable for bags requiring particular good foldability.

In application, woven fabrics formed from synthetic yarns having linear densities of about 40 denier to about 1200 denier are believed to be useful in the formation of the airbag according to the present invention. Fabrics formed from yarns having linear densities of  
20 about 315 to about 840 are believed to be particularly useful, and fabrics formed from yarns having linear densities in the range of about 400 to about 650 are believed to be most useful.

While each of the panels may be formed of the same material, the panels may also  
25 be formed from differing materials and or constructions, such as, without limitation, coated or uncoated fabrics. Such fabrics may provide high permeability fabric having an air permeability of about 5 CMF per square foot or higher, preferably less than about 3 CFM per square foot or less when measured at a differential pressure of 0.5 inches of water across

5 the fabric. Fabrics having permeabilities of about 1-3 CFM per square foot may be desirable as well. Fabrics having permeabilities below 2 CFM and preferably below 1 CFM in the uncoated state may be preferred. Such fabrics which have permeabilities below 2 CFM which permeability does not substantially increase by more than a factor of about 2 when the fabric is subjected to biaxial stresses in the range of up to about 100 pounds force may be particularly preferred. Fabrics which exhibit such characteristics which are formed by means of fluid jet weaving may be most preferred, although as noted previously, weaving on jacquard and/or dobby looms also permits seam production without the need for any further labor-intensive sewing or welding operations.

15 In the event that a coating is utilized on one or more material panels, neoprene, silicone urethanes or disperse polyamides may be preferred. Coatings such as dispersed polyamides having dry add on weights of about 0.6 ounces per square yard or less and more preferably about 0.4 ounces per square yard or less and most preferably about 0.3 per square yard or less may be particularly preferred so as to minimize fabric weight and enhance foldability. It is, of course, to be understood that aside from the use of coatings, different characteristics in various panels may also be achieved through the use of fabrics incorporating differing weave densities and/or finishing treatments such as calendaring as may be known to those in the skill of the art.

25 While the airbag cushions according to the present invention have been illustrated and described herein, it is to be understood that such cushions may also include additional components such as shape defining tethers, gas vents, and the like as may be known to those in the skill of the art.

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With regard to comparable airbag cushions, the following table presents comparative seam usage factors for other well known and commercially available airbag cushions. The labels used are those used within Standard & Poor's DRI, a well known publication which denotes many different types of products offered for sale to the automotive industry.

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**TABLE 1***Fabric Usage Index Factors for Comparative Commercially Available Airbag Cushions*

<u>S&amp;P DRI Number</u>	<u>Total Amount of Fabric Used (m)("C")</u>	<u>Available Inflation Airspace Volume (L)("B")</u>	<u>Fabric Usage Factor (C/B)</u>
GM-C4	4.47	95.00	0.0471
W202	4.34	129.00	0.0337
GM4200	3.89	90.00	0.0432
414T	4.35	128.00	0.0340
CY	4.34	128.00	0.0339
CF	4.53	128.00	0.0354

**TABLE 2***Fabric Weight Index Factors for Comparative Commercially Available Airbag Cushions*

<u>S&amp;P DRI Number</u>	<u>Total Weight of Fabric Used (gm)("C")</u>	<u>Available Inflation Airspace Volume (L)("B")</u>	<u>Fabric Weight Factor (C/B)</u>
GM-C4	1082.66	95.00	11.396
W202	1050.90	129.00	8.147
GM4200	941.49	90.00	10.461
414T	1053.27	128.00	8.229
CY	1050.90	128.00	8.2109
CF	1095.67	128.00	8.560

The 414T and CF bags listed above are tilted cushions for use in conjunction with relatively horizontal dashboards. The others are used in conjunction with substantially vertically configured dashboards.

Generally, an airbag module manufacturer or automobile manufacturer will specify what dimensions and performance characteristics are needed for a specific model and make of car. Thus, airbag inflation airspace volume, front panel protection area (particularly for passenger-side airbag cushions), and sufficient overall protection for a passenger are such required specifications. In comparison with those commercially available airbag cushions listed above, the inventive airbag cushions which meet the same specifications (and actually exceed the overall passenger protection characteristics versus the prior art cushions) but require less fabric, less seam length for sewing operations, and thus cost appreciably less than those competitive cushions. The dimensions and seam usage, fabric usage and fabric weight factors for the inventive bags (which compare with those in Tables 1 and 2, above, directly, and as noted) are presented below in tabular form:

**TABLE 3**

*Fabric Usage Index Factors for Inventive Airbag Cushions in Correlation to the S&P DRI Numbered Airbag Cushions Requiring Similar Dimensions and Performance Characteristics*

Correlated Bags by S&P DRI Number	Total Amount of Fabric Used (m)("C")	Available Inflation Airspace Volume (L)("B")	Fabric Usage Factor C/B)
GM-C4	2.41	95.00	0.0253
W202	3.50	129.00	0.0271
GM4200	2.58	90.00	0.0287
414T	3.64	128.00	0.0284
CY	3.64	128.00	0.0284
CF	3.50	128.00	0.0273

5

TABLE 4

*Fabric Weight Index Factors for Inventive Airbag Cushions in Correlation to the S&P DRI Numbered Airbag Cushions Requiring Similar Dimensions and Performance Characteristics*

	Correlated Bags by <u>S&amp;P DRI Number</u>	Total Weight of Fabric Used (gm)("C")	Available Inflation Airspace Volume (L)("B")	Fabric Weight Factor (C/B)
10	GM-C4	582.08	95.00	6.127
	W202	600.51	129.00	4.655
	GM4200	574.18	90.00	6.380
	414T	632.12	128.00	4.938
15	CY	547.84	128.00	4.280
	CF	632.12	128.00	4.938

Clearly, the inventive bags, which possess the same available inflation airspace volume and front fabric panel area as the comparative prior art commercially available cushions (bags), require much less in the way of total fabric utilization, which thus correlates into overall much lower effective fabric usage factors. Furthermore, as noted above, in standard crash tests, these inventive bags (cushions) either performed as well as or outperformed their commercially available, more expensive, counterparts.

Passenger side airbags, or airbag cushions, have primarily two modes of attachment in an automobile, namely, front mount and top mount (FIGS. 29 and 30). Because of the injuries caused to unbelted occupants and small occupants (5 percentile), OEM's are moving towards a top mount application. With the top mount application and a dual stage inflater, the deployment sequence is controlled in smart systems with the help of computer algorithms that determine the deployment characteristics. From the airbag design point of view, this fairly complicates the design. Now airbag designs have to be developed that will wrap around the instrument panel and have attachment below the instrument panel in such a way to angle the bag toward that occupant. This kind of attachment (because of the desired bag profile) introduces residual stress at the attachment point which is already a weak link

5 in the system. Also, such complicated bag profiles correspond to ineffective fabric usage and increase reinforcements and sewing labor, which ultimately increases the cost.

In accordance with the one embodiment of the present invention, a new passenger  
airbag cushion and method is provided which allows for the existing attributes of the front  
10 mount design as shown, for example, in **FIG. 1** or **FIG. 19** of the drawings which can be  
modified to provide a top mount profile as shown in **FIG. 30** of the drawings.

With reference to **FIG. 1** of the drawings, an improved bag for front mount  
application is shown with fabric utilization in the 95% or greater range. In the existing  
15 configuration this bag may not be used for a top mount application. Most of the attributes  
realized with this design will be offset in changing to a top mount application as shown in  
**FIG. 27** of the drawings based on conventional approaches to top mount passenger side  
airbags.

20 Fabric utilization is reduced to less than 80% in the layout shown in **FIG. 27** of the  
drawings. Hence, in accordance with the present invention, a passenger airbag and method  
is proposed where the front mount application is changed or modified for top dash mount  
application without any tradeoff in fabric utilization and the like. In accordance with this  
particular embodiment of the present invention, a front mount bag is changed to a top mount  
25 bag by precutting a slit in the fabric in the main panel near the bottom portion of the bag  
(**FIG. 28**). When a seam is sewn to connect or close the slit, the fabric gathers around the  
seam to create an offset in the mount as shown in **FIG. 30**.

5

In accordance with the present invention, top mount bags can be made in a similar fashion to front mount bags without a tradeoff in fabric utilization.

Turning now to Figures 28 and 30 of the drawings, there is shown a fabric web 310, wherein eight fabric panels to be cut 312, 314, 316, 318, 320, 322, 324, and 326 have been outlined. Also, specific fabric pieces to be removed and slits 328 330, 332 within the two largest fabric panels 312, 314 are outlined as well. The fabric web 310 in this specific example comprised nylon 6,6, 630 denier yarns, woven on a jacquard loom into a fabric 10 comprising 41 picks by 41 ends per inch.

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In accordance with the present invention, slits, notches or openings 306, 308 in panels 314, 312 are added to offset the mouth configuration instead of utilizing two separate side panels in accordance with conventional passenger bags. In accordance with the present invention, fabric utilization is above 95% as in the front mount bag with more than a 50% reduction in total length of the seams, 40% reduction in fabric usage and predominated by straight seams.

20

The opening, slit, notch, or the like 306, 308 can be of any shape depending on the required profile of the bag. The slit or notch can also be positioned in a non-symmetrical fashion at the bottom or side of the panel depending on the relationship of the instrument panel design and the windshield design. This approach can be used for any given shape of the starting panel.

25

5           In accordance with a particular example of the present invention, the front mount fabric layout of FIG. 1 has an overall length of about 2.17 yards or 1,991.7 millimeters.

10           While specific embodiments of the invention have been illustrated and described, it is to be understood that the invention is not limited thereto, since modifications may certainly be made and other embodiments of the principals of this invention will no doubt occur to those skilled in the art. Therefore, it is contemplated by the appended claims to cover any such modifications and other embodiments as incorporate the features of this invention which in the true spirit and scope of the claims hereto.